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JOURNAL

OF THE

BOARD OF AGRICULTURE

OF

BRITISH GUIANA.

VOL X OCTOBER, 1916. No 1.

# Fighting the South American Leaf Disease of Hevea.

WORK on the difficult problem of finding an effective method of checking the leaf disease of *Hevea brasiliensis*, which has been causing so much trouble and anxiety in this and neighbouring colonies of South America, goes on steadily and results have already been obtained which give promise of furnishing planters with a simple and reliable remedy. We reprint in this number Mr. Bancroft's comprehensive "Report on the South American Leaf Disease of the Para Rubber Tree," which gives a full summary of our knowledge up to the end of June, 1916, with suggestions for treatment adapted to the conditions obtaining in this colony: we are able to add information gathered from a pamphlet issued by the Department of Agriculture, Surinam* which contains a brief *précis* of the research carried on by Dr. Gerold Stahel, the Government Botanist of the neighbouring Dutch colony, and his method of treatment.

In this paper Dr. Stahel anounces that his investigation into the leaf disease—upon which, we understand, he has been engaged for the last twelve months—is now finished, but the Bulletin he has written on the subject cannot appear

*Mededeeling van het Department van den Landbouw in Suriname, No 6 (September, 1916.)

until January or February, 1917 as the drawings and photographs have to be reproduced in Holland. He finds that the disease is caused by a fungus with three different forms of fructification—(a) *perithecia*, bearing ascospores, and found on old leaves some two months after they are full-grown, (b) *pycnidia*, giving rise to pycnospores, and borne in large numbers on leaves not yet fully mature, and (c) *conidia* (the "*Scolicotrichum* form" of fructification) produced in immense numbers on the young leaves.

Dr. Stahel investigated the behaviour of these respective spores, and found that the conidia germinated in water after about two hours, while, sown on a young leaf, they germinated freely. The germ-tubes produced by them penetrated the cuticle of the leaf within ten hours and could be observed between the epidermal cells and in the tissue of the leaf itself after twenty hours. Drying the conidia, he discovered, killed them within fifteen hours. The pycnospores germinated easily in water and nutritive solutions, but the germtubes, even when produced on young leaves, never exceeded two to three thousandths of a millimetre in length and did not develop further. The ascospores exhibited a similar facility in germination, but when sown on young leaves did not easily penetrate the cuticle, and even after 22 hours had not pushed their way between the epidermal cells into the body of the leaf. Drought killed these spores also in a few hours. Moreover, he found that the production of ascospores was small even when the leaves bore a large number of perithecia. Sometimes he had difficulty in obtaining ascospores for his experiments. The leaf tissue, he remarks, dies off round the perithecia, which then die off themselves in many cases.

From these results Dr. Stahel concludes that the pycnospores play no part in spreading the disease, that the ascospores, although not quite harmless, are an almost negligible factor, and that the fungus is propagated—and infection carried—almost entirely by the conidia of the *Scolicotrichum* fructification, which cause the "dark gray-green, velvety spots" on the young leaves which are so characteristic a symptom of the disease. Full-grown leaves, he considers, are only slightly infectious—the young leaves, when diseased, are on the other hand a source of great danger.

The course of treatment recommended is based on the susceptibility of the spores to drought. As Hevea trees are not uniform in their time of "wintering," specimens putting out young leaves and shoots are always to be found at any given time on all estates of any size. Hence a favourable *nidus* for the development of conidia is constantly present. Dr. Stahel therefore recommends that steps should be taken to ensure that no young leaves or shoots are present on an estate for a period of two, three or four weeks. Deprived of their only chance of germinating, the conidia will dry up and die, and the estate will start "with a clean slate" as it were. He admits that the treatment will have to be repeated, as the ascospores are not quite harmless but can reproduce the conidial stage in time. What period must elapse between treatments must be left to experience to show. He also points out that it is a necessary corollary of his treatment that neighbouring estates must put the method into practice simultaneously; and that any plantation refusing to combat the disease must cut out its Hevea trees altogether. Co-operation in these matters is a commonplace of modern plant sanitation.

The means of securing the absence of young leaves and shoots over the estate for a given period is simple. Dr. Stahel points out that the leaves in *Hevea* are borne close together at the ends of the branches, and that a sharp cacao knife on the end of a long pole is all the apparatus necessary. He suggests that during the dry season, when little latex is flowing and the labour force is slack, the hands might be spread over the fields pruning the leaves. As these dry up, the fungus will be killed automatically by the dry conditions, there being no need to collect the leaves and burn them. He calculates that one man should be able to treat one or two big, or a larger number of small trees, in the course of a day.

It would be obviously unfair to criticise Dr. Stahel's work in the absence of the Bulletin giving a full account of his research and the details of his experiments and technique. His discovery of the vulnerability of the ascospores is a most important one. He says himself that at first he overestimated the importance of these spores, and that it was his work of the last two months which convinced him that they were almost negligible as carriers of infection. Biologically,

the fact is quite comprehensible. "Resting spores" are of the greatest value in temperate climates which have a definite winter period, during which a delicate structure like a fungus mycelium could hardly exist. In the tropics it may well be that such spores are a superfluity. We know of several fungi which seldom or never produce fructifications at all, but are propagated by sterile mycelium only: and of others which produce practically conidia only, so favourable are the conditions. This leaf disease fungus is very possibly in the act of "cutting out" the ascospore stage in its life-history, and throwing its whole dependence on its conidia. If so, it is a most fortunate thing for the rubber planter.

One word of warning is perhaps necessary. It does not follow that the conditions in which the leaf disease exists in Surinam are precisely the same as those obtaining in British Guiana, or that methods of control which are indicated for one colony can be applied without modification to the other.

Thus we have Dr. Stahel's opinion that "die-back" due to *Diplodia* does not enter into the problem in Surinam,** whereas there can be no doubt that this saprophyte plays a very important secondary part in the destruction caused by the leaf disease in this colony. It would not be too much to say that the *Diplodia* (=*Thyridaria tarda*, Bancroft) is in some parts of British Guiana *the* determining factor in the death of the Hevea tree. As this deadly pest is a saprophyte (*i.e.* an organism which lives on dead wood) it would be unwise for planters to neglect the pruning back of dead twigs and branches and their immediate destruction, suggested by Mr. Bancroft. Dr. Stahel says he cannot recommend this step—in fact, he actively discountenances it in Surinam—but the reasons for this advice he holds back until his Bulletin appears early next year. Judgment on this point must be deferred until then, and until Mr. Bancroft has completed his work on the disease, upon which he is now actively engaged. Meanwhile, we must thank Dr. Stahel for having provided us with an alternative method of fighting the leaf fungus, a method which is well worth trying on the large scale in estate conditions in this colony.

** Mededeeling van het Department van den Landbouw in Snriname, No. I., (November, 1915.)

## The Service of Science.

Science is a stern mistress, who gives the best within her only to those who follow her unflinchingly, however difficult the task, however remote the prospect of pecuniary gain or of self-aggrandizement, their sole hope being that they too may add to mankind's knowledge of truth, so that future generations may profit by the sacrifices of the present. This has been the spirit of the past; it must also be the spirit of the present and of the future. Science is moving onward, swiftly, relentlessly, unflinchingly—no half-hearted followers for her—the weak fall by the wayside; there is no place for those who have not the patience to acquire the necessary knowledge, the strong press forward in fierce rivalry, each striving for the ultimate goal—a perfect human knowledge, by which from any given premisses the logical conclusion may be drawn with unerring accuracy. *Finis coronat opus.*

—"The Spirit of Organic Chemistry," by Arthur Lachman.

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## Artificial Sand Dunes.

The formation of arificial dunes for the protection of the land from the inundation of the sea has been successfully practised in some places. On a tide-washed flat lying between the Zuiderzee and the North Sea, a sand-dyke was thrown up between 3 and 4 miles in length, enclosing 1,600 acres of land, and against this the wind-blown sand has accumulated to the width of a mile; and a similar result followed the construction of a bank called the Zyperzeedyk.

—"The Sea-Coast," by W. H. Wheeler, M. Inst. C.E.

# The Cultivation of Limes. IV.

*By Professor J. B. Harrison, C.M.G., M.A., &c., Director and C. K. Bancroft, M.A., F.L.S., Assistant Director, Department of Science & Agriculture.*

## CROP.

Investigations made by Mr. A. J. Brooks and published in the West Indian Bulletin* show that the average length of time taken for the fruit of the lime to mature, from the time of falling of the petals of the flower, is sixteen and a half weeks. This relates to the ripening of the fruit in the West Indian Islands. No accurate measurements have been made in this colony, but it is probable that the fruit takes a somewhat longer time to mature owing to the greater and more evenly distributed rainfall of the colony, more especially in the districts away from the coastland. Two crops are obtained during the year, one in March to June and the other in September to December, but small pickings are made almost throughout the remaining months of the year.

There is a considerable difference of opinion as to the yield which may be expected from lime trees growing under suitable conditions in this part of the world. An estimate of one barrel (160 lbs.) of limes per tree made by Dr. Nicholls for Dominica in 1882, cannot be regarded as an accurate one at the present time, although subsequent estimates of a barrel per tree have not infrequently been made. The probable mean yield on a large scale in British Guiana is a little more than half a barrel, or about 90 lbs. per tree for trees of 8 to 10 years of age or older.

## MANUFACTURE.

There are two processes in use for obtaining the juice from the fruit—the one by ordinary compression and the other by expression by a mill. The former is said to be confined to very small proprietors in the West Indian Islands and is not now in use in British Guiana. On pp. 6, 7, 8, and 9, Vol. IX., No. 1 of this Journal different types of mills are given.

* Vol. XII. p. 509

The complete process of manufacture comprises the extraction of the "otto of limes," the expression of the juice and recovery of the essential oil, the concentration of the juice or the manufacture of citrate of lime. In some cases fresh limes are exported and in other cases raw lime juice.

A barrel of limes in this colony yields about 8 gallons of juice. The yield may be expected to vary in different localities under different climatic conditions. The citric acid content of the juice also exhibits marked variation according to climatic conditions. Fourteen ounces of citric acid per gallon is a high acid content; an average content is between 12 and 14 ounces.

## LIME PRODUCTS.

The produce of a lime plantation may be put on the market in several different forms.

(1) *Green Limes* are sometimes shipped. For this purpose they should be gathered as soon as they are full-grown, *i.e.,* before they are ripe. The ripening process takes place when the fruit is in transit.

(2.) *Essential Oil* is obtained from the outer part of the rind of the fruit. That which is obtained before the limes are crushed is known as otto of limes. It is prepared as follows:—The limes are compressed by rolling with the palm of the hand on the spiked pan of an apparatus known as an "écuelle pan." This consists of a saucer-shaped receptacle attached to which is a hollow brass handle. Some of the oil contained in the rind is extracted in this way and flows into the hollow handle. On allowing the liquid to stand the oil separates from a watery layer and is poured into a receptacle and allowed to deposit a yellow crystalline substance. The deposition being complete the oil is filtered and exported. It is doubtful whether at normal market rates écuelling would be profitable in this colony. It requires very cheap labour and is better suited to the West Indian Islands. The yield obtained is small, from 1 to 2 oz. per barrel of fruit.

The juice is next subjected to distillation when the essential oil comes over with the steam and is condensed by means of a condenser. By a special contrivance the water is allowed to run away and the oil is retained.

Distillation is effected by direct fire or by means of steam. The yield of distilled oil is about 4lb. per 100 gallons of juice.

(3.) *Raw Juice.*—The preparation of raw juice requires the careful sorting of limes in order to retain the best fruit which alone should be employed for this purpose. It is shipped in casks.

(4.) *Concentrated Lime Juice.*—This is effected by evaporation either in iron or copper tayches, or in steam-heated vats. The former are more convenient for use on the small scale. The latter enable the concentration to be more easily controlled. Evaporation is conducted until a concentration of 9 to 1 or 10 to 1 is effected. The specific gravity of the boiling liquid indicated by an ordinary glass hydrometer graduated for use at 60° F. is then 1.250 to 1.255.

(5.) *Citrate of Lime.*—The preparation of the Citrate is effected by neutralising the juice, heated almost to boiling, by chalk or more usually slaked lime. It is customary to mix the lime into a paste with water and then to add it to the juice. The point of neutrality must necessarily be determined with some care. This may be done by testing the juice with a little of the mixture of lime and water at intervals during neutralising until a point is reached where there is no effervescence. The point of neutrality is better determined by litmus paper or more accurately still by the use of the indicator phenolphthalein.

The mixture is allowed to settle, when the citrate falls to the bottom. The mother-liquor is run off and the citrate washed with boiling hot water. Drying is effected primarily by means of a centrifugal machine and subsequently by heating to 100° C. or a little more. Careful storage is required.

Shipments of all of the above products have been made from Britsh Guiana and have been favourably reported on. The industry is one which deserves attention not only from local but also foreign capitalists.

(*Concluded.*)

## The Manatees at the Botanic Gardens.

THE opportunity was taken on Monday, October 29, to weigh and measure the manatees (*Trichechus Manatus*) which have for many years been interesting inhabitants of the lakes in the Georgetown Botanic Gardens. The lakes are in process of being deepened, and the manatees were moved from Lake I. to Lake II., in the presence of a large and intensely interested party who attended at the invitation of the Director of Science and Agriculture. A body of the Gardens' employees put in a strenuous time noosing the great beasts by the tail and towing them over the smooth mud of the communicating channel and up the bank to the weighing machine. Once caught in the slip-knot, the animals seemed quite resigned to their fate; but considerable amusement was caused by the terrific commotion and the cataracts of mud which followed on the frantic flapping of the spadelike tails before the larger specimens were secured. A meed of praise is due to the labour gang, who, under the direction of Messrs. Ward and Service, handled the heavy brutes without accident or injury to man or beast.

At one time there were as many as six manatees in the lakes at the Botanic Gardens. Two died and four now remain. These consist of a large male and a large female, presented by the late Sir Cavendish Boyle, K.C.M.G. (then the Hon. Cavendish Boyle, C.M.G.) in March, 1895; a female born three months later to the above-mentioned female; and a small male born in 1905-6.

The weights and measurements, as recorded on October 29, 1916, were as follow:—

*No. I.—Original Male.*

| | |
|---|---|
| Weight .. .. .. | 558 lbs. |
| Length .. .. .. | 9 ft. |
| Girth .. .. .. | 6 ft. |

*No. II.—Original Female.*

| | |
|---|---|
| Weight .. .. .. | 523 lbs. |
| Length .. .. .. | 8 ft. 5 ins. |
| Girth .. .. .. | 6 ft. |

*No. III.—Female, born about August,* 1895.

| | | | | |
|---|---|---|---|---|
| Weight | .. | .. | .. | 517 lbs. |
| Length | .. | .. | .. | 8 ft. 6 ins. |
| Girth | .. | .. | .. | 5 ft. 8 ins. |

*No. IV.—Male, born* 1905-6.

| | | | | |
|---|---|---|---|---|
| Weight | .. | .. | .. | 262 lbs. |
| Length | .. | .. | .. | 6 ft. 4 ins. |
| Girth | .. | .. | .. | 4 ft. 2 ins. |

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**The Teaching of the War.**

What difference has the war made? I believe it has opened the eyes of the nation to the perils which arise from the neglect of intellectual things, the satisfaction with book knowledge, the inattention to facts, the concentration on physical prowess, and on a passive kind of material prosperity—the widespread ignorance of natural facts even among our leaders, and consequent contempt for investigation and expert knowledge.

—" Nature," January 13, 1916.

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**The "Water-Net."**

The current number of the Journal of the Quekett Microscopical Club (Ser. 2, Vol. XII., No. 77) contains an interesting note by Mr. James Burton on the fresh-water alga, *Hydrodictyon reticulatum*. This remarkable plant, which takes the form of a net, floating in the water, is not very often seen in England. For more than thirty years Mr. Burton looked for it almost in vain; though it was known to have occurred in past times in the lake in Kew Gardens. In the autumn of 1914, however, it made its appearance in that locality in enormous quantities, so that boatmen were employed in gathering it in with rakes and piling it in heaps on the shore. In less than a month's time after first seeing it Mr. Burton was unable to find a single specimen. He compares this sudden outburst of *Hydrodictyon* to the so-called " breaking of the meres," caused by the sudden and rapid multiplication of other algæ.

" Nature,"—February 3, 1916.

# Rice at the Experimental Fields—Crop of 1915.

*By Professor J. B. Harrison, C.M.G., M.A., Director; C. K. Bancroft, M.A., F.L.S., Assistant Director; and R. Ward, Agricultural Superintendent, Department of Science and Agriculture.*

Varieties of rice of proved value were planted in the North Field in large scale trials in duplicate half-acre plots. Planting comenced on May 2, and was completed on May 8. Reaping was begun on October 3. The crop, therefore, took five months to mature.

The yields obtained from the different varieties were as follows:—

| *Selected Varieties.* | *Bags of 140lbs.* per acre.* |
|---|---|
| No. 75 .. .. .. | 35.12 |
| Creole .. .. .. | 33.73 |
| H 6 .. .. .. | 33.73 |
| *Strains—* | |
| No. 75, strain 6 .. .. | 36.28 |
| " " " 7 .. .. | 35.48 |
| H 6, strain 1 .. .. | 33.18 |

The duplicate and quadruplicate comparative trials on one-sixteenth acre plots of certain varieties gave the following mean results:—

| *Variety.* | *Bags of 140lbs. per acre.* |
|---|---|
| No. 75, strain 1 .. .. | 34.95 |
| " " " 2 .. .. | 40.30 |
| " " " 4 .. .. | 39.11 |
| " " " 8 .. .. | 34.29 |
| Demerara Creole, strain 2 .. | 36.73 |

The crop reaped was not so good as that of the previous year, but was above the average. The Creole variety again gave a higher yield than its average for the past eleven years.

* Approximately three bushels.

### MANURIAL EXPERIMENTS.

The manurial experiments were continued in the North Field. Twenty-six plots, one-eighth of an acre each, were cross-dressed with sulphate of ammonia at the rate of 100 lbs. per acre: twenty-six plots, their duplicates, did not receive any nitrogenous manuring. The results obtained showed that the mean return from the manured plots was 34.84 bags per acre, and the mean of the unmanured plots 33.91 bags. The results confirm the conclusion arrived at from previous experiments, *i.e.*, that in the period during which the rice land is fallow an accumulation of nitrogen sufficient for the needs of the crop takes place, and no increase in yield can be attributed to the addition of nitrogenous manure.

### RICE IRRIGATED WITH ARTESIAN WELL WATER.

The plots in the D'Urban Park were planted on March 24, and reaped on September 18, the crop taking six months to mature. The results obtained were as follow:—

| *Variety.* | *Bags of* 140*lbs. per acre.* |
|---|---|
| No. 75 .. .. .. | 24.76 |
| Creole .. .. .. | 21.26 |
| H 6 .. .. .. | 19.48 |

This was the sixth crop grown on the D'Urban Park land under irrigaiton with artesian well water. The order of yield of the three above-mentioned varieties was the same as in the North Field.

The total amount of seed padi specially selected was 28,487 lbs. of which about 26,500 will be available for distribution.

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### Science in School.

I trust that while science will be taught in all schools, we shall after this war see that some of our larger and more important schools make a speciality of this important subject.

The masters in our schools should insist that science and modern languages should be regarded as equally important as classical teaching and the rewards for proficiency gained in their study should be as great.

—Prof. H. A. Strong in " Science Progress," April, 1916.

# Report on the South American Leaf Disease of the Para Rubber Tree.

*By C. K. Bancroft, M.A., F.L.S., Government Botanist and Assistant Director, Department of Science and Agriculture.*

The history of the Para Rubber industry of British Guiana dates back to the year 1895 when seeds of *Hevea brasiliensis* were imported into the colony by Sir Everard im Thurn and by the Botanic Gardens. The seeds were obtained from the Royal Botanic Gardens, Kew. Subsequently supplies were obtained from Trinidad in 1896-99. Plants from these were distributed to different parts of the colony and form the oldest trees existing in the colony at the present day. During the past seven years regular annual supplies of seeds have been obtained from the Botanic Gardens, Singapore, and other supplies at irregular intervals from Ceylon. Plants from these seeds form the greater part of the existing cultivated area. In addition to these, seeds and "stumps" have been obtained by private individuals from Ceylon, Trinidad and Dutch Guiana. The greater part of the cultivated area has therefore been raised from seed obtained directly from the same stock as the rubber trees of the East which were derived from trees of the Amazon.

The area under cultivation in Para Rubber in the colony is at the present time 4,687 acres, an increase of 4,277 acres since 1907. Of this, 1,155 acres are situated at or near the coastlands, 2,854 acres on the banks of the Demerara and Essequibo Rivers, and 678 acres in the North West and Pomeroon Districts of the Colony. The cultivated areas occupy parts of all three counties, including the North West District. The furthest distance inland where an area of appreciable size is planted is 55 miles from the coast direct.

The different soils on which the plant is being cultivated are roughly classed as follows:—

(1) The heavy clay front lands near the coast;

(2) Those further aback and on the banks of the rivers, of a looser texture and usually containing surface layers rich in organic matter;

(3) The orange to red lateritic soils further inland, comprising undulating land and possessing loose almost sandy surface layers scattered here and there in small patches.

Statistics of rate of growth of the tree in different parts of the colony are given in the following tables:—

GIRTHS MEASURED AT 3 FEET FROM THE GROUND.

| Age of Trees. | Issorora (N. W. District). | Onderneeming (Essequibo). | Christainburg (Demerara River). |
|---|---|---|---|
| 2 years | 6 ins. | 9 ins. | 4 ins. |
| 3 ,, | ... | 15 ,, | 8 ,, |
| 4 ,, | 15 ,, | 17 ,, | 13 ,, |
| 5 ,, | 19 ,, | 19 ,, | |
| 6 ,, | ... | 20 ,, | |
| 7 ,, } | 26 ins. | 22 ,, | |
| 8 ,, } | | | |
| 9 ,, } | ... | 26 ,, | |
| 10 ,, | ... | 30 ,, | |
| 11 ,, | ... | 33 ,, | |
| 12 ,, | ... | 35 ,, | |
| 15 ,, | ... | 41 ,, | |

Average measurements of girths at three feet from the ground in other places are :—

| Locality. | Age of Trees. | Average Girth. |
|---|---|---|
| Look Out (Essequibo River) ... | 5 years ... | 26 ins. |
| | 2 years, 6 months ... | 13.25 ,, |
| Hills Plantation (Mazaruni River) | 2 years, 9 months ... | 10.66 ,, |
| Vreed-Styn (Demerara River) ... | 2 years ... | 7.50 ,, |
| | 4 years, 4 months ... | 22.50 ,, |
| Canal No. 1 (Demerara River) ... | 5 years, 2 months ... | 17.50 ,, |
| Tuschen (West Coast, Demerara) | 6 years ... | 21.50 ,, |
| Canje Creek (Berbice) ... | 2 years, 10 months... | 13.50 ,, |

The above figures show that a satisfactory rate of growth has been obtained in different parts of the colony under different conditions of rainfall, temperature and humidity and on soils of different nature. On the heavy clay soils of

parts of the coastlands the growth of the trees has, however, been poor.

Measurements of yields obtained from trees of different ages indicate that a majority of the trees will be available for tapping when they attain the age of five years. Yields obtained from trees growing at Pln. Tuschen, Pln. Providence, Onderneeming Farm (coast lands), the Hills Plantation (Mazaruni River), Pln. Christianburg (Demerara River), Aruka Estate (Aruka River), Issorora Experiment Station (Aruka River), during tapping experiments extending over a period of three years have indicated that a yield of 300 lb. of dry rubber per annum can reasonably be expected from an acre of trees which have reached maturity, viz., 8 years of age or more.

Experimental tapping conducted on areas of appreciable size shows that for trees in full bearing the cost of production per lb. of dry rubber should not exceed 30 cents, inclusive of all charges.

## DISEASE OF THE PARA RUBBER TREE.

Disease of the Para Rubber tree induced by micro-organisms of vegetable nature have occurred ever since the inception of the rubber industry, in different parts of the world In 1904 Hennings recorded three leaf fungi on *Hevea brasiliensis* in Brazil, viz., *Dothidella Ulei*, P. Henn., *Aposphaeria Ulei* P. Henn., and *Phyllachora Huberi* P. Henn. Although no account of these diseases was published the two former were said to be very injurious. They were found on the leaves of seedling plants. The first named, from accounts received later, is of common occurrence on wild *Hevea* in Brazil.

Subsequently other leaf fungi were recorded on *Hevea*, viz., *Helminthosporium heveae*, Petch, and *Gloeosporium heveae*, Petch, (Ceylon 1905.)

In 1908 a leaf disease is reported to have affected Hevea plants in the nursery of the Botanic Gardens, Surinam. It was thus reported on:—" Though the disease is a very infec-'tious one, trees in favourable circumstances are probably

"little susceptible to it. The fast spreading in the above-"mentioned case must be ascribed to various accidental cir-"cumstances, especially to too close planting." (Mevr. A. E. van Hall de Jonge, Bull. No. 24, Dept. van den Landbouw, Surinam). Petch reports that specimens of a similar disease were sent to Ceylon from Bolivia. The cause of the disease was not recorded.

While little or no extensive damage to cultivated trees has been reported as having been effected by the fungus organisms attacking the leaves of the tree, considerable loss has arisen from attacks by fungi affecting other parts of the plant. The three which call for special mention are *Fomes semitostus*, Berk, *Hymenochaete noxia*, Berk, and *Thyridaria tarda*, Bancroft, the two former attacking the root and the last named the stem of the tree.

THE SOUTH AMERICAN LEAF DISEASE.

The South American Leaf Disease of *Hevea*, which forms the subject of this report, is, as will be shown later, probably identical with the leaf disease of Brazil (*Aposphaeria Ulei*) mentioned above, and is known to be identical with a leaf disease occurring in Dutch Guiana.

In 1909 a leaf disease appeared among planted *Hevea* trees growing at Greenheart Camp, between Wismar and Rockstone, Demerara and Essequibo Rivers. These trees were grown from seed obtained originally from Singapore, on sandy soil derived by the decomposition *in situ* of granite rock. Spots appeared on young and old leaves, withering of young leaves occurred, and in some instances complete defoliation of the trees. The symptoms were identical with those of what is now called the South American Leaf Disease. These trees recovered their normal foliage but were again attacked in 1911 on which occasion the Economic Biologist Mr. G. E. Bodkin, obtained inoculation on healthy trees, thus showing the disease to be infectious. Trees which are growing at the present time, on the same site, have to the writer's knowledge been affected with the South American leaf disease since 1913. Although no determination of the cause of the disease was made in 1909, there is little doubt that the two diseases were identical. It may therefore be

accepted that the South American Leaf Disease first appeared in British Guiana in 1909.

A tree of *Hevea confusa* growing on Canal No. 1 was affected with symptoms similar to the above in 1910. In the following year a large *Hevea brasiliensis* tree on the same land was attacked.

A record appears of a leaf disease affecting plants growing at Rubberton Estate (Barima River) in 1911. The plants were imported from Surinam. The disease was, however, not described.

Subsequent to this there is no record of a leaf disease occurring in the colony until May, 1913, when an outbreak occurred in the nurseries of the Hills Plantation (Mazaruni River). Leaves of the trees were examined and diagnosed by the writer as affected by a fungus, probably of the genus *Fusicladium* and were sent to the Royal Botanic Gardens, Kew, for examination. Massee considered the organism as a species new to science and named it *Passalora heveae*, Massee.

Dr. Kuyper described a leaf disease of *Hevea* trees in Dutch Guiana in 1912 which he attributed to a new species of fungus *Fusicladium macrosporum*, Kuyper. This, as will later be shown, is identical with the South American Leaf Disease occurring in British Guiana. It is probably also identical with the disease mentioned by Van Hall in Surinam in 1908.

The diseases occurring in British Guiana and Surinam are regarded as being the same although the causative organism has been called by different names. This conclusion is based on the result of examination of diseased specimens and the presence in both instances of organisms of identical characters. Unfortunately, specimens of *Aposphaeria Ulei*, the cause of the disease in Brazil, are not available for comparison; there is therefore no conclusive proof of the identity of the Brazilian and the South American leaf diseases. Yet the symptoms are similar in either case and the causative organisms closely allied systematically so that the two diseases are probably of the same origin. Further, more recently

(1914) Griffon and Maublanc have described fructifications of *Fusicladium* and *Aposphaeria* along with perithecia of *Dothidella Ulei* on *Hevea* leaves in Para. The illustrations published, according to Petch, resemble closely those of Kuyper. This leaves little room for doubt that the two diseases are of identical origin.

While it was recognised that the opinion of more than one writer on the subject of leaf diseases of the Para rubber tree was probably erroneous in that, owing to its deciduous habit, the tree was regarded as less likely to be subject to damage from attacks by leaf fungi than coffee, cacao, or limes, the disease both in Surinam and British Guiana was at first regarded as of a sporadic nature and little fear of extensive damage was entertained. During the past two years, however, the disease has spread considerably not only in British Guiana but also in the adjacent colony of Surinam.

Following on the diagnosis of the disease occurring at the Hills Plantation in 1913, an account of its nature was published in the local Journal of the Board of Agriculture (Journal B.A. Vol. VII., No. 1, 1913), and remedial measures were recommended for its extermination. This outbreak was, however, soon followed by the appearance of the disease in several other parts of the colony. Early in 1914 it appeared on the left bank of the Demerara River, and simultaneously at Plantation Christianburg. In the beginning of 1915 it was reported from the Canje Creek and the Aruka River; and more recently it has been observed to be present in small quantity on the coastlands and in the Pomeroon District. It is, therefore, distributed over the whole of the colony except the Essequibo Coast and the greater part of the Demerara Coast. It does not occur on the Essequibo Coast; on the Demerara Coast and the Pomeroon District it is not present in large quantity; in all other parts of the colony where rubber is grown it is prevalent.

It is of interest here to record that among the large number of plants growing at the Botanic Gardens—30,000 to 50,000—the disease has not appeared.

Trees six years old, growing on the Upper Barima River near to Arakaka have been attacked. These trees are distant 50 miles from any other *Hevea* plants.

The widespread occurrence of the disease is significant of the virulence of the attack. The disease is now present in several parts of the colony in epidemic form. In some localities almost all of the trees are affected in some degree.

As will be shown later it has been concluded after careful investigation that the present effect on the trees is not entirely attributable to the South American Leaf Disease, but that a considerable amount of damage has been caused to the trees by what is known as "die-back," following on attacks by the leaf disease. It is, therefore, desirable here to distinguish between those two effects.

## SYMPTOMS.

Briefly, the symptoms of the "leaf disease" are as follow: —The production of grey-green spots on young leaves which soon crumple and fall away from the tree is a common symptom when the disease is in its most virulent form. Sometimes the margins of very young leaves are blackened and shrivelled. The occurrence of black spots on the leaf-stalks and of black cankered areas on the green stems is less common. The older leaves are spotted with small black circular spots and are sometimes pitted with holes.

Defoliation occurs readily when the young leaves are attacked, the twigs becoming bare. New leaves are put out, and these too may be shed. A third and fourth renewal of leaves may occur. In this latter case the young twigs usually die and leave the crown bare.

From the above it will be seen that the actual damage caused by the leaf fungus is limited to the leaves and tender parts of the shoots. It is not uncommon, however, to find that where the disease is prevalent the branches of the trees commence to die back. Death of the branches proceeds downwards to the trunk and if this is not arrested the whole tree may succumb. The common symptoms of "die-back" are:—

The dying-back of branches of the tree towards the stem is the characteristic symptom. The disease proceeds downwards, killing off whorls of branches in succession and may eventually reach the base of the tree.

Sometimes the dying-back is arrested by natural causes and the effect confined to a few branches only. In some cases too, death occurs on one side of a branch only, the remainder being unaffected. This is also due to the growth of the fungus having been arrested.

The bark cracks and exposes the blackened wood beneath.

From the diseased bark are exuded black tendrils, like curled hairs. This occurs more particularly under damp conditions.

Diseased wood possesses a greyish discolouration.

"Die-back" is due to fungus of an entirely different nature to that which causes the leaf disease.

### PHYSIOLOGY OF THE SOUTH AMERICAN LEAF DISEASE.

The results of field and laboratory investigations of the two fungi will now be given in brief:—

The youngest leaves when affected show the presence of dark-coloured spots frequently at points on the margin. They may occur either on the upper or the lower surface of the leaf. In these spots almost all of the cells both of the epidermis and mesophyll are dead. The collapse of the tissues causes the leaf to become crinkled. Examined superficially, abundant hyphæ can be seen to rise from the spots, growing erect and producing one or two-celled, oblong, frequently more or less curled conidia at their apices. These hyphae are simple and usually entire. They are of a pale brown or yellow colour. The dead tissues are penetrated by the sterile part of the mycelium. An increase in the number of spots on these young leaves is followed by wilting, the collapse of the leaf tissue consequent upon the destruction of certain parts of it. The mycelium which penetrates the internal tissues does not spread throughout the leaf; its action is confined to a definite area or part of the leaf Each spot represents a separate infection. As a natural reaction defoliation takes place, both leaflets and leaf-stalks being cast off as in the normal process of "wintering."

Young leaf-stalks sometimes become spotted, though not so frequently as the leaves. Here again the action of the mycelium is localised.

On the older leaves the spots are more sharply defined. The action of the mycelium here is also local. After the leaves have reached a certain point in development they are not usually cast off, but remain attached, presenting dried spots produced by the action of the fungus and sometimes holes from which the dead tissue has fallen away.

The old leaves bear another form of the fungus on the spots, which occurs on the upper as well as on the lower surface. It takes the form of black excrescences which frequently form circles or ringlets measuring usually 1 or 2 mm. in diameter, but are sometimes larger. These are spore cases (pycnidia) in which are borne unicellular hyaline spores which are probably of a more durable nature than the conidia. Fresh pycnidia can be seen on dry leaves which have lain on the ground for some weeks.

Older leaves sometimes show what is probably the highest form of the fungus, the ascospore stage, though this is seldom met with. Sections of old spots have demonstrated the occurrence of asci, along with old pycnidia, the ascospores being hyaline and two-celled. This stage requires further investigation. The three forms, the conidial, pycnidial and perithecial, occur on the same spots in different stages of development.

The tender parts of shoots show black spots usually elongated and attaining a length of 1 inch or less. They frequently become cracked and give rise to a "canker." They bear conidia abundantly. Infection on these is, however, by no means so common as on the leaves.

In addition to attacking leaves and tender shoots the leaf fungus attacks the inflorescence of the plant resulting in severe cases in complete destruction of the floral organs and consequently the absence of setting of seed. Seed is seldom produced where continued defoliation occurs. One of the results of the present epidemic has been the reduction in large quantity of the number of seeds.

The fungus, in common with many fungi which attack deciduous trees, has more than one form. The conidial stage arises first and produces spores (conidia) which are evidently intended for rapid reproduction of the disease. By germination on the leaf or young stem they are capable of ini-

tiating the disease. The conidia germinate in water or in 1 per cent. cane sugar in the dark within twelve hours. The second form of spore (pycnospore), with which there appears to be associated an ascigerous stage, is concluded by analogy with fungi of a similar nature to be intended to tide the fungus over a "resting" period. It should, however, be borne in mind that as all of the trees seldom "winter" at the same time the conidial stage is in continual existence.

The above indicates the principal means of propagation of the disease and consequently certain lines which should be followed in treating it.

## CULTURAL EXPERIMENTS.

All attempts to grow the organism in artificial culture media have failed. The apparent highly developed parasitism of the conidial form is in all probability connected with this.

## CONDITIONS AFFECTING THE SPREAD OF THE DISEASE.

An examination of the rubber cultivation of the colony shows that the disease obeys the general rule which governs the prevalence of diseases of a similar nature, viz., that it is most prevalent where large areas of pure *Hevea* are being grown. In small holdings with mixed cultivation it is by no means so prevalent as on the large plantations. It is, however, essential to the successful cultivation of the *Hevea* tree that it should be grown in pure culture; "and he who attempts to grow a plant in large numbers in pure culture must run the risk of epidemic." It is probable that intermediate belts of forest would reduce the chance of the disease appearing on a cultivation. The interposition of belts of forest trees, 150 feet broad, would probably aid in arresting the spread of the disease.

The fact that in the more humid parts of the colony and in those in which a higher day temperature prevails, the disease is most prevalent, indicates that humidity favours the growth of the conidial form of the fungus. Observations

made in different parts of the colony have led to the conclusion that this is the case. Damp conditions generally favour the growth of organisms of this nature. It may, therefore, be expected that rubber growing in the interior of the colony would be more susceptible than that near to the coastland.

Overcrowding, due to too close planting, is a factor closely connected with the above and one which should be considered along with it.

From the above conclusions as to the growth of the fungus and the mode of spread of the disease one might be tempted to assume that the disease would be less prevalent during dry than in wet weather. Lack of rain does not, however, necessarily always indicate that dry conditions of the atmosphere prevail. Observations conducted in the North West District recently, during a dry spell of several months, have shown the disease to be more prevalent in dry weather than it was during the rains. This may possibly be due to a combination of favourable conditions of climatic environment, but it is more probably due to the fact that in normal wet weather the tree is not so liable to defoliation although affected by the disease. On the Mazaruni River the disease has usually been more prevalent in wet weather.

It has been already stated that the conidia of the fungus germinate within twelve hours. In some cases young leaves, less than a week old, have been observed to bear conidiophores and conidia. It is concluded, therefore, that reproduction of the conidial form by means of conidia may occur within a week after the commencement of infection. This indicates that the conidial form is a means of very rapid propagation.

Observations have shown that the leaves are more susceptible at certain periods of their existence. The very young leaves are not infrequently comparatively free from the disease, and old leaves which have passed a certain stage of development are frequently not affected. Between these two periods of development there appears to exist the most susceptible stage, the point at which the leaf is most easily infected.

28 MAY 1936



From observations conducted in the field the period of greatest susceptibility appears to lie between the ages of one and two weeks, the leaflets being then about 3 to 5 inches long. The exact cause of this may appear somewhat obscure, but in the light of recent investigations conducted on a disease of a similar nature it is possible that the susceptibility is connected with the development and movement of the stomata or pores on the leaves. It is also possible that it may be connected with the formation of the cuticle on the leaves. This matter requires further investigation.

The presence of the disease in all parts of the colony among trees growing under widely diverse conditions as regards the nature of the soil precludes the possibility of the soil playing any important part in connection with the disease. Amelioration of soil conditions, more particularly in regard to drainage, may be expected however to be beneficial in that it would tend to produce more robust plants.

## ORIGIN OF THE DISEASE.

The origin of the disease in the colony is not known. The fact that it appeared on the Barima and Mazaruni Rivers in 1911 and 1913 respectively, on plants obtained from Surinam, suggests the possibility of the disease having been introduced from Surinam. Yet the disease is supposed to have occurred in the colony some years before (Greenheart Camp, 1909). The fact that a similar disease occurs on wild *Hevea* in Brazil suggests that the South American Leaf Disease may be present in wild species of Hevea in the colony. It has been met with on *Hevea confusa* and has also been reported from Surinam on *Hevea guianensis*. Whether it occurs on other species of *Hevea* is not known. A careful search on areas affected by the disease has failed to reveal its presence on any other wild plant. It is a highly developed parasite, in fact a pure parasite, and in view of what obtains usually in the case of such fungi it is probable that its attack is confined to closely related species of a genus. There are not to our knowledge any wild Hevea trees growing in the North West District; yet planted trees at Arakaka 50 miles from any other *Hevea* trees have been infected. It is probable therefore that the spores of the fungus can be taken for long distances by the wind.

## SUMMARY.

The conclusions based on what has been written above are as follow:—

(1) The Rubber industry of the colony at the time when the South American Leaf disease began to make its presence felt showed promise of making rapid strides in development. The existing conditions were such as to favour the extension of the industry.

(2) Leaf diseases have been known to affect the Para Rubber tree since 1904: but none have hitherto been regarded as likely to cause serious damage. The deciduous habit of the tree was regarded as a natural means of protection against extensive damage by a leaf disease.

(3) The South American Leaf Disease was first recognised in the colony in 1909. In its early appearance it was sporadic. In 1914 it increased abundantly, and at the present time it occurs in all parts of the colony. It is not, however, prevalent on rubber growing on or near to the coastland.

(4) Similar diseases occurring in Dutch Guiana and Brazil are concluded to be identical with the leaf disease occurring in British Guiana.

(5) The damage which has been done to rubber trees in the colony is not all due to the leaf disease, but also to what is known as "die-back" (and probably to certain root diseases as well).

(6) The Leaf Disease is caused by a fungus, *Fusicladium macrosporum*, Kuyper, which is propagated by minute spores of three forms. One is intended for rapid reproduction and the others together probably constitute a resting stage. The former occurs on young leaves and twigs when recently attacked: the two latter principally on old and on fallen leaves.

(7) Conditions which influence the disease are:—

(a) Presence of large numbers of the plant in pure culture.

(b) Humidity and a high day temperature.

(c) The disease need not be more prevalent in wet than in dry weather. The trees are not so liable to defoliate in wet weather and hence, other conditions being equal, would suffer more damage in dry weather.

(d) Leaves are most susceptible to attack between the ages of one and two weeks and when usually 3 to 5 inches long.

(8) The origin of the disease is not known. It has been met with on two wild species of *Hevea* growing in the forest; but it is not known to occur on any other wild plant. The fungus is such as is likely to confine its attack to closely allied species of plants.

THE "DIE-BACK" DISEASE.

The symptoms of this disease have already been described. The disease formed the subject of careful investigation by the writer and others in the East for several years. Studies both in the field and laboratory during the present epidemic have led to the same conclusions in regard to its origin and mode of spread as were formed in the East several years ago. They are as follows:—

(1) The disease is caused by a fungus which though in habit a saprophyte, *i.e.*, a liver on dead vegetable matter, is capable under certain conditions of damaging living tissue.

(2) It is capable of infecting at an unbroken surface but gains an entrance to the stem through a wound or dead surface.

(3) Having effected an entrance the fungus spreads through the wood causing the death of living tissues and giving rise to what is known as "die-back."

(4) The fungus is propagated by means of spores produced on the bark of the affected stems.

(5) The fungus lives readily on dead and dying parts of plants.

Examination of cankered areas caused by the leaf fungus on young shoots frequently shows the presence of the "die-

back" fungus in association with the leaf fungus. In microscopic preparations it has been possible to observe the presence of the "die-back" fungus in the wood of younger branches affected with the canker. In the light of results of previous study of "die-back" it is concluded that the "die-back" fungus probably gains an entrance through these cankered areas.

The younger branches of the trees sometimes die as the result of continual defoliation. Examination shows that the starch content of branches which are being continually defoliated is much reduced and in some cases is almost negligible. This leads to the assumption that death is due primarily to starvation. When dead these branches are frequently found to be affected by the "die-back" fungus and in later stages it has been possible to trace the growth of the mycelium of the "die-back" fungus from the dead tips of the branches to the wood of older parts of the stem. The mycelium of the fungus does not always affect all of the wood of a branch. It may proceed down one side of the branch leaving the other side apparently healthy. This partial action is common in the case of the *Diplodia* fungus.

These observations lead to the conclusion that the "die-back" fungus gains entrance to the tree through dead young parts of the branches whose death is due to the action of the leaf fungus. In other words the leaf-fungus provides the "die-back" fungus with a means of entrance.

The "die-back" disease described by Petch from Ceylon in 1905 was due to a fungus *Gloeosporium alborubrum*, Petch, which attacks the young parts of the shoots and provides the "die-back" fungus with a means of infecting the stem. The present combined effect of the leaf fungus and the "die-back" fungus is regarded as an instance of a similar nature.

TREATMENT.

The actual cause of epidemics or sudden outbursts of disease over considerable areas is not known. But it is generally considered by the highest authorities that such outbursts are the result of favourable atmospheric conditions coupled with the presence of the host plant in sufficient quantity.

Different diseases which now and again assume the proportions of an epidemic are usually caused by fungi which are quite general and are always present in the district. Epidemics are fortunately usually sporadic in their occurrence. During the presence of an epidemic measures should be so directed as to reduce the loss from disease to as small an amount as possible. It can scarcely be hoped that anything short of the destruction of all living plants in an affected area will wipe out the disease. In view of this the following measures are suggested for application in the present instance. They are based on the conclusions arrived at by the study of the disease as set out above in the report:—

## SPRAYING.

*Spraying.*—In view of the rapid propagation of the disease by means of a conidial form it is very probable that the application of a fungicide which would prevent or retard germination or development of the spores would be effective in reducing the loss from the disease. For this reason the application of a lime and sulphur mixture to the leaves was recommended in 1913, when the disease appeared among nursery plants at the Hills Plantation. Subsequently, Bordeaux Mixture was recommended after the disease appeared in the fields. The reason for this was that although Bordeaux Mixture is known to possess better qualities as a fungicide than the lime and sulphur mixture, lime and sulphur had been found to be very effective in nurseries in the Federated Malay States. Early sprayings with Bordeaux Mixture on young plants gave satisfatory results at Plantation Christianburg, at Issorora Experiment Station, and at the Aruka Estate. With an increase, however, in the amount of the disease among the older trees it was not possible to cope with it owing to the spraying machines in use at the time being unsuitable for the purpose. It was not possible to spray the older trees satisfactorily on account of the machines being too small. This defect has, however, been remedied in several instances and it is now hoped that all cultivators will employ machines capable of spraying the tallest trees.

Bordeaux Mixture is prepared from copper sulphate (96 per cent. pure), quicklime and water. Varying proportions of these constituents have been and are still in use. The

commonest are the 6-4-50 and the 4-4-50 mixtures, *i.e.*, copper sulphate 6 or 4lb., quicklime 4lb., and water 50 gallons. An improved method of preparing the mixture is the employment of clear lime water instead of milk of lime, this being said to render the mixture more quickly effective. The lime should be present in such quantity as to ensure that the whole of the copper is precipitated. To determine this the mixture when prepared should be tested by holding a bright knife in the liquid. A deposition of copper shows that there is copper in solution and more lime water must be added. The preparation should be conducted as follows:—

Dissolve 6lb. of copper sulphate in five gallons of water in a wooden or earthenware vessel; slake 4lb. of lime in a little water and put it in a tub with 45 gallons of water, stir and allow to settle, pour off the clear liquid and mix it with the copper solution; stir for five minutes.

The immediate effectiveness of the mixture prepared in this way will obviously be of advantage in treatment of the leaf disease.

## SPRAYING MACHINES.

A knapsack sprayer is sufficiently good for use with young trees, those which are under twelve feet high. There are many types of knapsack sprayers on the market, but the best is the pneumatic or compressed air sprayer. A good type of pneumatic sprayer is sold by the "Four Oaks" Spraying Machine Company, Sutton Coldfield, Birmingham, England, for $16.80 in England. A short extension bamboo rod is required of 6ft. 6in. in length, and costs $3.00.

For taller trees a more powerful sprayer is needed. A "Battle" pattern sprayer is sold by the "Four Oaks" Company for $66.00 (18 gallons capacity) and $80.40 (25 gallons capacity). Extension rods of 15ft. and 10ft. 6in. are sold for $6.00 and $4.20, respectively.

Messrs Walter Voss and Company, Cartlton Works, Millwall, London, E., supply a Vermorel "Cascade" sprayer for use with tall trees at a cost of about $90.00.

Barrel pumps are useful although not so easily handled as the above machines.

Whatever type of sprayer is used extension rods must be employed for tall trees.

It is desirable that spraying be conducted as rapidly as possible in order that the leaves may be protected before they attain the condition of greatest susceptibility to attack from the fungus.

The employment of battery sprayers involves a considerable saving of time and is therefore recommended. Battery pneumatic sprayers are sold by the " Four Oaks " Company for $189 (battery of six sprayers) and $311.40 (battery of of twelve sprayers). They possess the advantage of keeping from six to twelve men continually spraying without any pumping on their part. The same results can be obtained by the use of an oil engine feeding several hoses at the same time.

A fine nozzle is required, the primary object in spraying being to deposit the mixture on the foliage in the form of a mist.

HOW TO SPRAY.

Spraying should not be done direct on the foliage, but at some little distance away, the mist being encouraged to settle gradually on the leaves and stems.

Spraying should not be done during very wet weather.

A suitable adhesive for use with Bordeaux Mixture can be prepared by heating 2 lb. rosin with 1 lb. washing soda in 1 gallon of water until clear, and adding 1 gallon to every 24 gallons of Bordeaux Mixture.

It has been pointed out above that the leaves are most susceptible to attack between the ages of one and two weeks. Spraying should therefore be conducted before the young leaves are a week old.

In spraying due regard should be paid to the condition of the foliage on the trees. On each cultivation where the disease is present trees will be found in different stages of de-

foliation. In each area, therefore, trees should be selected and marked out for spraying before the leaves reach the age of one week, i.e., when about from 1½ to 2½ inches long. Trees whose leaves have attained maturity need not be sprayed until all others have been attended to, as the effect of the fungus on such leaves is comparatively slight.

A second application of the mixture should follow as soon as possible after the first.

The present price of sulphate of copper locally is 16 cents per lb. Quicklime costs half a cent a pound. From 2-4 gallons of the mixture will be sufficient for large trees, the cost of which is 4 to 8 cents.

SANITARY MEASURES.

*Destruction of Fallen Leaves.*—It has been stated above that the pycnidia of the fungus occur on fallen leaves. These, therefore, are a source of infection. They should either be burnt or buried. Burning is most effective, but it requires careful supervision. On pegassy soil burning is risky owing to the danger of setting fire to the pegass.

Destruction of leaves should form part of the routine work of the estate and should accompany the weeding. The fields should be weeded clean and the weeds and leaves stacked between the rows and burnt or buried.

Where the trees are closely planted they should be judiciously thinned out. It is the general opinion that one hundred trees or a few more per acre are sufficient for the economic working of a cultivation in this colony.

It is essential that the tips of branches killed by the leaf disease should be removed and destroyed.

Since wild Heveas are capable of harbouring the disease they should be destroyed whenever they are found near to a cultivation.

The fact that the "die-back" fungus lives readily on dead wood necessitates the destruction of the latter on the plan-

tations both in areas where the disease occurs and also where it has not been met with. Dead branches should not be left lying about, but should be gathered into small heaps and burnt on the spot. Dead parts of other plants which may be growing along with the rubber, such as coconuts, coffee, etc., should be treated in a similar manner. Such a method of sanitation reduces the spore production of the fungus.

### TARRING WOUNDS.

The "die-back" fungus causes greater damage to unhealthy trees than to healthy ones. Attempts should therefore be made to ensure a vigorous growth of the plant by practising good methods of cultivation. A good access of light should be obtained by avoiding close planting. Excessive tapping should be avoided. The trees should be provided with adequate drainage.

As a preventive measure all wounds should be tarred; by a wound is meant any lesion which exposes the central woody core of the plant. Special care should be taken to tar the cut ends of stumps, and to remove such lower branches as may die off owing to excessive shading and to tar the surface of the trunk which thus becomes exposed. Coal tar should be used; it possesses two distinct advantages above Stockholm tar, viz., it is more permanent and it offers better protection against fungi. The tar should be warmed slightly before it is used; it should be applied by means of a brush in the form of a thin layer. It should not be allowed to run down the sides of the branches or trunk. The cut surface should be allowed to dry slightly before it is tarred.

Diseased branches should be removed. The indication of the extent of disease is furnished by the wood. In removing a diseased branch it is necessary to cut back until a point is reached where the wood is not discoloured and then to remove another six inches of the branch. A sloping surface should always be left after removal. The smaller branches may be removed by a pruner such as is used on cacao estates. Several types of these pruners are on sale locally. They are provided with long handles and are capable of removing branches up to two inches in diameter. In removing a large

branch it will be advantageous to make more than one cut. First, a cut should be made eight or ten inches from the trunk from below upwards and should go half-way through the branch; a second cut should be made two inches further from the trunk from above downwards and should go through the branch. Finally the stub should be sawn off flush with the trunk. Stubs must not be left, since they never heal over and invariably die back to the trunk. All large branches must be removed by means of a saw.

Deep tapping and consequent exposure of the wood should always be avoided.

THE OCCURRENCE OF ROOT DISEASES IN THE COLONY.

It has been mentioned above that diseases affecting their roots have been responsible for some of the damage to the trees in the colony. Two kinds of root diseases have been observed to be present on estates in the interior of the colony, but they have never been found near to the coastland. The reason for this is that the fungi causing these diseases are both products of the forest and disappear from the land as the forest timber decays. They are the root disease caused by *Fomes semitostus,* which produces white or orange-coloured strands on the roots, and the "brown root" disease which causes the formation of brown or almost black incrustations occurring principally on the tap root, and which is due to *Hymenochaete noxia.*

Both of these diseases are well known in the East and can be found described in most text-books on the *Hevea* tree. As to how far the damage due to them has affected the rubber cultivation in the colony is not known.

# Lessons with Plants in British Guiana.

*By the Editor.*

*"It is finding answers to questions which chiefly deserves to be called Science."*—L. C. Miall, F.R.S., in "Teaching and Organisation."

IX.

## ADAPTATIONS TO EXCEPTIONAL CONDITIONS.

*(Continued.)*

Let us now consider the case of plants which flourish in trenches, ponds and swamps. It is a commonplace of cultivation that good drainage is an absolute necessity. Experience shewed, long before Science gave any explanation of the phenomenon, that economic plants require plenty of air round their roots, if good crops are to be expected. Wild plants have to be satisfied with what they can get, or perish; yet simple observation proves that very many such plants do exceedingly well in badly drained soil, waterlogged ground, trenches and pools, and even in salt swamps. How do they do it?

The coast lands of British Guiana are particularly well adapted to the study of these forms of plants. Any trench almost will furnish us with examples. In the Botanic Gardens—the happy hunting ground of the student—the giant "water-lily," *Victoria regia*, with its huge tray-like leaves and magnificent flowers, the smaller Nymphaeas, and the Sacred Lotus, *Nelumbium speciosum*, root in the mud send up their long leaf and flower-stalks to the surface. Cut off some of these stalks and examine the section. What do you notice? How long is it before the water-lilies wilt? Note the character of the under-water parts of the *Victoria*. It is probable that you will wish that you had come provided with a good strong pair of gloves. Why? Do you note anything else in the trenches in which the plants are growing? If not, seek a trench which is being cleaned out, or search the irrigation trenches in the Nursery Look carefully at the old leaves of the *Victoria*, and try and discover what

causes their "nibbled" appearance. Compare the stalks of the water-lilies with those of the *Nelumbium*. What difference in habit may explain the difference noted in the stalks of these plants?

TRENCH CONDITIONS.

Let us look for a moment at the character of the environment of a trench plant from the point of view of (1) food supply, (2) air supply, (3) support. The mud at the bottom of the trench will yield ample mineral matter for solution, so that our plants will be actually surrounded, over the greater part of their surface, with food substances in a form just fit for absorption and assimilation. Provided that the nutrient solution can pass easily through the cell-walls, there will be no need for the elaborate system of root-hairs and conducting vessels which are a feature of land plants. Running water is well oxygenated, but trench water is not. Probably it contains a good quantity of carbon dioxide gas dissolved in it, derived from decaying matter. Sunlight penetrates clear water to a considerable depth, but trenches are not usually filled with very clear or very colourless liquid, so it seems probable that only where the water is in contact with the under side of the leaves can photosynthesis utilise the carbon dioxide of the water. For breathing purposes the trench water is obviously useless, but air cavities *within the plant body* might very well supply the place of an external atmosphere. Stomata would need to be on the only exposed area of the plants—the upper surfaces of the leaves—and large intercellular spaces connecting with these would furnish an efficient mechanism of gaseous interchange. Do you find any evidence of such a state of things? Thirdly, water affords excellent support as every swimmer knows. Plants immersed in it have no need of highly developed woody tissue to keep their heads up and their leaves spread out to the sun. Those which rear themselves *above* the surface will, however, require some stiffening. How does this consideration apply to the plants we are studying?

THE SMALLER TRENCH PLANTS.

Quite small plants, with delicate leaves and stems, can do with even simpler arrangements. Provided the water can

penetrate the cell-walls, and provided the whole plant floats on the surface so that it is freely exposed to the sunlight, photosynthesis can go on easily, and the oxygen liberated in the process will be available for respiratory purposes. We thus find our ponds and trenches covered with such forms as *Azolla caroliniana*—a pretty little water-fern, often of a rich red-brown colour—*Salvinia auriculata*, another water-fern, rootless but having one leaf in each whorl modified into the semblance of a much-branched root, and with hairy leaves which are not easily wetted owing to the air entangled on their surface; *Pistia stratiotes*, the Water Lettuce, and its minute relative, *Lemna minor*, the Duckweed, and, locally, *Wolffia stenoglossa*, a plant so reduced (it is the smallest flowering plant known) that it consists merely of a tiny green thallus about half the size of a "bitt." In many trenches species of *Utricularia* can be found, their delicate feathery leaves studded with tiny bladders and their beautiful yellow flowers held well above the surface. They, too have dispensed with roots, and manage to get along very well without them. Their carnivorous habits will be considered later. Everywhere the Blanket-weed (*Cabomba aquatica*) flourishes—its much-divided, fan-like, under-water leaves very characteristic, and, in the season, its dainty shield-shaped floating leaves supporting the stalks of the small, yellow blossoms. In the trenches along the East Coast we have met with two other interesting aquatic forms—the rootless *Ceratophyllum demersum* or Hornwort and *Ruppia maritima*.—locally called "shrimp-grass"; both of which well deserve study in the light of what we have said, but especially for their remarkable flowers and fruit.

Now pluck a water-lily with a good piece of stalk and place it in a glass of water with as much of the plant as possible out of the water. Note what happens, and reflect that if water can penetrate the epidermis of the plant easily, owing to the absence of protecting, waterproof "cuticle," it can get out again as easily, while lack of vascular tissue means poor conduction of water—and endeavour to find an explanation of what you observe.

### SWAMP PLANTS.

Great areas of the low-lying lands of the colony are thickly covered with trees of great size and evident healthi-

ness in spite of the fact that for months at a time the ground is flooded. In such a soil two great biological necessities are (1) air for the roots, (2) efficient support for the tree trunk. Now a walk through such a typical swamp forest as may be found a short way up the Demerara river will shew that the ground is covered with a mass of fine, wiry roots, mingled with others which resemble nothing so much as large croquet-hoops. On higher land, such as can be met with at the Settlement, Mazaruni River, the swamp land is chiefly to be found in the valleys between the hills, but the conditions are better, natural drainage is more effective and the ground is covered with a tangle of large roots which run close to the surface only occasionally rising as big "knees" or as loops which top any water likely to lie for any length of time on the surface Some of these belong to the Cork-wood tree (*Pterocarpus Draco*), some to the Paddlewood (*Aspidiospermum excelsum*). The latter is remarkable for the fluted character of its trunk, the ridges standing out a foot or more from the bole forming a very efficient support at the ground level. Similar "buttresses" may be seen in the Silk-cotton (*Bombax Ceiba*) which reaches an enormous size in the swamp forests of the lower Courantyne river and has a tremendous spread of almost horizontal branches. Another type of supporting root may be noticed in the "Wild Mango." In this tree thin roots are sent out copiously one above the other from the lower part of the trunk, and these curve gracefully downwards and enter the ground some feet away from the main stem. They may be called "stilt roots," and a precisely similar type occurs in the "Black Mangrove" (*Rhizophora spp.*) After reaching the ground the roots thicken up, and form a strong support.

In the true swamp forest, the "croquet-hoop" structures already mentioned are the pneumatophores or breathing-roots of the Manni (*Moronobea coccinea*), and no doubt they enable the main roots to get a good supply of air when the soil is covered with water. The Manni also sends out "stilt" roots, but so far as we have seen these are irregular in character and uncertain in development.

It is interesting to observe how the Palms of the swamp forest adapt themselves, in spite of their very different structure, to precisely similar biological soil conditions. Palm roots are produced at the base of the trunk in large numbers,

are thin and remain thin, but may run for long distances through the ground. Æta (*Mauritia flexuosa*) and Manicole (*Euterpe edulis*) palms are prominent members of the swamp forest and the wiry roots already mentioned are apparently aerating structures formed by these plants to overcome the difficulty of flooded soil. The Æta in addition sends up a number of stout vertical roots round the stem; but the Manicole appears to be content with giving its ordinary roots a high origin on the trunk—so high that in some cases they resemble true "stilt-roots."

THE MANGROVE FORMATION.

Of the considerable number of trees which have adapted themselves to swamp conditions, practically only three have managed to overcome the added difficulty of a saline soil water. When one considers the opening provided by the sea-shore—the ample supply of water, (salt water, it is true), the rich mud, the splendid light, and the absence of competition, it is remarkable that the "mangrove formation" is not more varied. It is evident from even a casual inspection that one tree s dominant on the coast-line, and that is the Courida (*Avicennia nitida.*) The true sea-coast is practically covered by a forest of Courida, but at the mouths of the rivers *Rhizophora Mangle* is prominent, while the so-called "White Mangrove" (*Laguncularia racemosa*), apparently a late comer to the formation, is to be found in both situations and is making a bold bid for dominance.

It is interesting to investigate the factors which determine the character of the coast flora, and to try and ascertain what special adaptations have enabled certain plants to surmount the difficulties caused by these factors. One factor s evidently the salt content of the ocean, but it seems improbable that the 3 per cent. or so of soluble salts in sea water would prove detrimental to many swamp trees. The gradual "education" they would receive as they pushed down the rivers and met increasingly brackish water, fluctuating with each tide, would soon enable them to thrive in water of a fair degree of concentration. Observation shows as a matter of fact, that very many plants are quite indifferent to contact with sea water—yet they are not able to win a permanent place in the mangrove formation. If the concentration of the soil water did not vary much, but remained constant at about

3 per cent., probably many more plants would obtain a footing; but experiment proves that the pools in which the mangrove trees grow are constantly changing in concentration. During the dry seasons the soil water may contain as much as 5, 6, or even 7 per cent. of soluble salts—and this proportion, at the onset of the rains, may fall to half in a few hours. From what we have learned of *osmotic pressure* we can see that these sudden changes must require special adaptability in a plant if it is to survive. If it is to utilise the soil water at all, it must maintain a concentration of its cell-sap greater than that of the water—but with a sudden fall in the salt content of the soil water the actual pressure in the cells of the plant will become so great that serious disorganisation may ensue. Not many plants will be so adaptable as this.

### "HYDATHODES."

One common feature of our three mangrove trees is that (except as very young seedlings) they do not form starch in their leaves. Starch in a leaf represents the excess of food formed over that used up or transported to the stem, and being a solid it can have no osmotic effect. Sugar in solution—and we know that cane-sugar is the first detectable product of photosynthesis—causes osmotic pressure, and no doubt it is used by the mangrove trees to preserve the balance against the changing concentration of the soil water. The excessive pressure consequent on a sudden lowering of the salt content of the soil water may be counteracted by special mechanisms; and we do find in both the Courida and in *Laguncularia* peculiar glandular structures called "hydathodes" on the leaves, which can excrete salt and other soluble substances and reduce the osmotic pressure in the cells of the leaf and so in the whole plant. It seems quite probable that this power of excreting salt—you will notice that the leaves of the Courida are always "sweating" *especially in dry weather*—is of the greatest advantage, and it may account in considerable measure for the fact that *Avicennia* is the dominant tree of the sea-shore in this colony. Whether or not *Laguncularia* does the same thing (it has highly complex hydathodes) is at present uncertain. *Rhizophora*, which has no hydathodes, evidently prefers situations where sudden changes of concentration in the soil water are not the rule.

THE DANGER OF DROUGHT.

Another factor in the sea-shore environment is drought—"physical drought" as opposed to the "physiological drought" due to the saline soil-water factor. The steady trade-wind and the hot sun have full play on the tropical shore, and a pool, inches deep to-day may be dry and caked hard in a week's time. Where the shore is composed of sand, drought is even worse, for such soil cannot retain water to anything like the extent clay does. Sand is practically fatal to the mangrove trees, even when they were originally established in the mud. In all the sea-shore plants, therefore, we find abundant *water-storage tissue*—large cells, often three or four layers deep—in which all-important liquid is conserved. Old leaves have this tissue best developed, and they supply the younger leaves which need water for their growth and functions.

Thus we see that at least three special adaptations are required for the successful mangrove tree—a means of aerating the roots, water-storage for the drought, and some mechanism for regulating the osmotic pressure in emergencies.

*(To be Continued.)*

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**The Treatment of Ankylostomisis.**

Dr. Howard states in his report that there are two methods of treatment (of ankylostomiasis) to be considered; the so-called daily method and the weekly or intensive method.

(*a*) The daily method consists of giving the patient ten grains of thymol each day, without purgatives or restrictions in diet or habits, for a period of four months.

(*b*) The intensive method is the giving of comparatively large doses of pulverized thymol (40 grains to adult), in capsules at weekly intervals, preceding and following each weekly treatment with a saline purge, and requiring the patient to abstain from food for three meals. It was by using this method of treatment in Meadow Bank village that more than 50 per cent. of cases treated were cured by the first and second treatment, or on the eighth day from the opening of the campaign in that village.

—"The Colonial Journal," April, 1915, No 4.

# Experiment Station Enterprise in Java.

DR. J. KUYPER, formerly Government Botanist in Surinam, gives some interesting information in a private letter regarding the organisation of the Sugar Cane Experiment Station in Java, in which he is at present employed.

These stations—of which there are three—chemical, technical and agricultural—were started, and are supported, entirely by the planters themselves, and are quite independent of the Government. Dr. Kuyper deals with the agricultural department only, with which he is personally connected, and leaves it to be surmised that the other two bureaux are organised in a similarly complete fashion.

The agricultural station is at Pasoeroen and has a Director and an Assistant Director, who are both graduates (Ph. D) in Botany. The Director concerns himself especially with general questions such as meteorological and climatological influences on cane cultivation, the fitness of special districts for cane, and so on, and receives reports from his officials who are spread over a district covered by ten estates. These officials have what Dr. Kuyper calls a "lower education," but are qualified to help the managers in making experiments and to send in to headquarters at Pasoeroen every kind of particular about their districts. They are termed "groeps adviseurs." All the experiments are, however, planned by the Director or his Assistant, who draw their conclusions from them.

Next to this section and quite apart from it, is the strictly scientific department, which is engaged in collecting purely scientific data. There is a Ph. D. in Botany for crossing and selection and another (Dr. Kuyper) for plant physiology; two bacteriologists (from the Technical University at Delft) for soil bacteriology and a chemist for soil analysis—all with high degrees. In addition to his scientific work, Dr. Kuyper occupies himself with the further education of the "groeps adviseurs." He travels round the estates, visiting each "groep," listening to their difficulties, giving them directions, and explaining

the object of each experiment and what it is hoped will be learned from it.

With this splendid organisation it is not surprising to learn that large profits are made in the sugar industry in Java. This year the crop has been a big one, prices have been high, and some estates have made a profit of from one to two million guilders (12 guilders = £1). Some of the Java varieties give about 6 tons (6,000 kilos) of sugar per acre. Evidently the Dutch planter believes in Science as an adjunct to business, and is not afraid to back his opinion.

### The Value of Research.

It would be difficult to assign within concise limits the causes of German supremacy in the dye industry; two main causes must be taken into account.

(1.) The attention devoted to research work.

(2.) The manipulation of the Patent Laws for the benefit the German firms.

As regards the first reason, it is probably too well known to need emphasising, but when it is remembered that the Hoechst works employ 350 research chemists, the Badische Company about the same number, and the Bayer Company nearly as many—in all about 1,000 university-trained chemists, many with the highest degrees—it will be realised that this great number of highly trained, scientific brains constantly engaged in discovering new dyes, evolving improved methods for making old ones, and so on, has exerted and will continue to exert a preponderating influence on the development of the German industry, and the fact that the two German firms at Ludwigshaven and at Hoechst were ready to spend a million pounds sterling in pure research work connected with the synthesis of indigo shows to what an extent the industry is entrusted to the hands of research chemists; and in the annual balance sheet of every German chemical firm a large proportion of the profits is set aside for research work as a matter of course, in precisely the same way as other portions are reserved for payment of interest, repayment of loans, and so on.

—"Science Progress," Jan., 1916.

## Answers to Correspondents.

**J. S.** (Plaisance).—The nutmeg grows best on a deep, rich, loam soil with a fair covering of humus. It does not do well on sandy soil. It requires a clear depth of drainage of three feet. Seedlings propagated in shaded seed-beds should be planted out when they are two feet high. When the plants flower an examination should be made to ascertain how many are male trees. One male to every ten female trees is regarded as sufficient for successful fertilisation. It is not possible to ascertain whether or not a plant is male or female before it flowers; and since the female alone bears fruit it is preferable to use grafted plants instead of seedlings.

The plants flower when they are seven years old. A full-bearing tree will produce about 1,500 nuts.

Generally speaking, the methods of cultivation employed for citrus and other similar fruits are suitable for the nutmeg.

Nutmegs flourish and bear best in the West Indies at an altitude of 800 to 1,200 feet, but they have been grown with success at 250 to 300 feet altitude. At lower altitudes they have usually failed.

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The Inspector of Districts.—The coconuts which do not bear fully-formed kernels, sent by you from Mocha village, have been examined. The nuts are of medium to large size, the kernels oblong and small and contain little meat. Parasitic organisms are not present.

The phenomenon is not uncommon in trees which are attaining, or have recently attained, the full-bearing stage. It is due either to some adverse physiological condition which prevents the trees from producing full-formed kernels, or else to fertilisation not taking place. In the former case, the plants, with the application of good cultivation and efficient drainage, will on suitable

land after a time produce normal fruits. When fertilisation does not occur the reason may be either the absence of insects or the degenerate condition of the sexual organs. The latter rarely occurs. If it does, there is no remedy, and the trees must be removed. I shall be glad to receive specimens of the flowers for examination.

Kernels which are not fully-developed are frequently found on young trees growing along Canal II., but there has been no case to my knowledge of such an occurrence on Canal III., where Mocha is. I have associated the phenomenon with the presence of acid soil water, *e.g.*, it is common in trees growing on peaty soil in the North West District. My opinion is that in these two districts, *viz.*, Canal II. and the North West the absence of fully formed kernels on young trees is due to acidity of the soil. The districts are unsuited to coconut cultivation, and the trees may not produce normal fruit until the thickness of pegass becomes reduced and the roots are able to reach the clay below.

C. K. B.

## Fixation of Atmospheric Nitrogen by Plants.

The most recent research on the subject, that of Dr. E. Mameli and Professor G. Pollacci, shows that not only the *Leguminosae* but many other flowering plants are able to make use of atmospheric nitrogen. Among flowering plants for which they claim this power are *Cucurbita pepo*, *Acer Negundo*, *Polygonum fagopyrum*, and they also ascribe it to such "Water-Ferns" as *Azolla caroliniana* and *Salvinia natans*. Frank long ago maintained the view that the power of assimilation of free nitrogen belongs to all green plants, and this view receives support from these recent researches.

"The Tropical Agriculturist," (Ceylon),

February, 1916.

## Hints, Scientific and Practical.

**The Bleaching of Palm Oil.**

As a problem of considerable technical importance, the catalytic bleaching of palm oil has been investigated by Sastry (Trans. Chem Soc. 107, 1828, 1915). The object is to oxidise the material as rapidly as possible, without its being otherwise attacked, and to avoid the labour and expenditure of time required if the oxidising agent has to be washed out of the oil The author's experiments consist in blowing air or oxygen through the oil in the presence of various catalysts, both oil and air being kept at a temperature of 80—90°C. Among the catalysts employed were salts of manganese, lead, cobalt, iron, and nickel. The best catalysts were found to be the salts of cobalt and manganese especially the borates of these metals. The larger the amount of catalyst present the shorter the time required. The bleaching effect is permanent, no colour having manifested itself after keeping for fifteen months. The author recommends finally the use of cobalt borate as the most suitable catalyst for technical purposes.

—" Science Progress," April, 1916.

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**Merit and Reward.**

RECENT events have indeed brought men of science into closer relationship with national affairs than ever before, and some attempts have been made to organise their efforts..... It will be noticed that in most cases, whether of Government panels of consultants or committees of scientific societies, the services rendered are gratuitous. No particular publicity has been given to this fact; and the majority of people are, therefore, unaware that the best expert scientific and technical knowledge has thus been placed freely at the disposal of the Government. As most scientific work is done for the good of the community instead of the personal profit of the individual, it is usually assumed officially that no payment need be made for it. The reverse is the case in other professions, where expert advice is never expected unless adequate fees are forthcoming. We were given several notable examples of this in a statement issued

by the Treasury a few days ago, showing the payments made to the Law Officers of the Crown since 1905. The total amount received by these officers during this period was nearly £250,000. In the year 1912-13, Sir Rufus Isaacs received £16,762 as Attorney General, and in the year 1913-14 Sir John Simon was paid £14,305. We are glad that attention has been directed to these generous emoluments for legal services, which are essentially non-productive and unprofitable; and we believe that when the public has been sufficiently enlightened as to the relative values of national work in law and science, a re-adjustment of the rewards made for it will be demanded.

—" Nature," January 6, 1916.

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**Sand Dunes as Sea Defences.**

BUT for the protection of dunes on low coasts whole provinces would be covered by by the sea, and but for the protection of dunes there would be little left of Holland andthe Netherlands. Kohl says that the people in Holland and Denmark " deal as carefully with their dunes as if dealing with eggs, and talk of their fringe of sand-hills as if it were a border set with pearls. They regard them as their best defence against the sea. These dunes are connected with their system of dykes, and sentries are posted all along their length to repair and guard them against wanton injury."

The sand on dunes is held together by the roots of the grass known as " marram " " star grass " or " sea-mat " (*Psamma arenaria*), the roots of which penetrate a long way into the sand for moisture, attaining sometimes a length of 36 feet, and thus hold the sand together, while the grass checks the action of the wind on the surface.

Taylor in a paper in the Philosophical Magazine, says that a single plant of matgrass, which he designates *Arundo arenaria,* will have lateral shoots radiating from a single stem 10 to 12 yards long, forming a circle 20 yards in diameter, and that a plant of this grass in one year will multiply itself five hundred fold.

The protection of sand-dunes has also been deemed a matter of sufficient importance to warrant legislative inter-

ference to prevent the abstraction of the plants which prevent it from drifting.

The protection of "marram grass" was held to be of so much importance that in an Act passed in the reign of George II. (15 Geo. ii.c. 33), after reciting that certain lands on the north-west coast of the kingdom were prevented from being overflowed by the sea by sandhills composed of such loose sand that in dry weather the sand was blown upon the adjacent land, to the damage of the land and the destruction of the banks, and that it was found by experience that the best way of preserving the hills was to plant them with a rush or shrub called "star" or "bent" grass, which was found to be an effectual means of keeping the banks firm; and that the sandhills were frequently damaged by persons cutting, pulling, and taking away the grass for making mats and brooms: it was therefore enacted that any person convicted of cutting or removing the grass without the consent of the owner, or unlawfully having such grass in their possession within five miles of the sandhills, should be liable to a penalty of twenty shillings, or in default of payment three months' imprisonment, and for a second offence one year's imprisonment. A similar enactment which had been passed in 1695 for the protection of bent grass in Scotland was confirmed.

—"The Sea-Coast," by W. H. Wheeler, M. Inst. C. E.

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**Protozoa in the Soil.**

In a recent note we remarked on the energy shown in America in the investigation of the problems of protozoa in the soil. The Journal of Agricultural Research contains a paper on the relative activity of protozoa in greenhouse and field soils. Mr. G. P. Koch has examined a number of soils in the endeavour to ascertain whether protozoa lead an active life in soils of different moisture content when the temperature is constant and when it is variable. The soil is stirred wth a few drops of sterile water and examined under the microscope for two minutes only, thus avoiding errors due to rapid development of encysted forms, as pointed out by Martin and Lewin. According to the author, active pro-

tozoa do exist in greenhouse soils but in very limited numbers, only six out of twenty soils examined showing a few trophic forms. Active protozoa are not found in field soils under normal conditions, but cysts invariably occur which become active in a favourable environment. The moisture content of the soils appears to be the chief factor in determining the presence or absence of active protozoa, while temperature, organic matter, and physical structure are of secondary importance. After heavy rain, when the soil is waterlogged, protozoa excyst and can be found in the active state in standing water. The time required for excystment was found to be longer than that given by previous workers. Small ciliates can excyst in one to two hours at 23°C.; at this temperature flagellates require six to eight hours and large ciliates forty hours. Both moisture and temperature appear to influence the period of excystment. Evidently the two-minute period of examination of each sample is well on the safe side. The author concludes that protozoa are too rarely active in field soils to operate as a limiting factor in crop production.

—"Nature," February 24, 1916.

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**Sugar Cane in India.**

CULTIVATION of the sugar cane in India is extremely ancient, and in many parts of the country it has laid a firm hold on the time-honoured rotation of crops. But this cultivation has not been progressive of late years, partly no doubt owing to the fact that the "jaggery" or "gur" which is its object is not exported to any considerable extent. The Indian gur market is self-contained and therefore unaffected by the wave of progress which has lately swept over agriculture in the tropics. But with regard to sugar, the matter is very different for, while in former times India took a prominent part in the manufacture and export of this substance, the local production has not kept pace with that in other countries and, in fact, sugar manufacture in India is a negligible quantity, and increasing supplies are introduced every year to meet the growing needs of the people. The Government of India has recently devoted marked attention to this matter and, as there appears to be no intrinsic reason

why India should not produce its own sugar, work has commenced in the Agricultural Department on this staple in two directions. In the first place, the local methods of manufacture need revision, and, in the second, the class of canes grown is of very poor quality. The latter subject having been exhaustively discussed at the meeting of the Board of Agriculture held at Pusa in November, 1911, it was decided to found a cane-breeding station whose main line of work was to determine the possibility of raising cane seedlings, and thereby to introduce new and improved varieties suitable to the local conditions of the country. This station has been located at Coimbatore in the Madras Presidency, where the canes are known to flower profusely year by year. It was opened in April, 1913, but a certain amount of preliminary work was first done in the Botanic Garden attached to the local Agricultural College.

—C. A. Barber, Sc.D., in "Memoirs of the Department of Agriculture in India," July, 1916.

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**The Products of Photosynthesis.**

It would seem that in all plants of which a systematic examination has been made (mangold, sugar beet, potato, snowdrop, grape vine, dahlia, etc.) saccharose is formed directly in the mesophyll of the leaf, whence it passes into the veins, mid-ribs and stalks, undergoing more and more complete inversion in its passage. The regulating mechanism is apparently such that a nearly constant concentration of cane sugar is maintained throughout the day and throughout the season in the mid-ribs and stalks, whilst the reducing sugars vary within very wide limits.

At first sight it would appear to be a clumsy and unnecessary contrivance for plans such as the mangold and sugar beet to form cane sugar in the leaf, then to transform it completely into hexoses in the stalks only to have to reconvert it back again into cane sugar in the roots; it would seem to be a simpler arrangement for cane sugar to travel as such to the roots. Most workers in this field have asumed this to be the case. It is a striking fact that even Girad's (1884) data show an enormous preponderance of the hexoses over the saccharose in the leaf-stalks of the sugar-beet (the hexoses being 5 to 10 times the cane sugar, which generally

was small); but he was apparently so struck by the novel observation of the relatively large proportion of cane sugar in the leaf, that he quite ignored the significance of the stalk analyses, concluding that the saccharose passed *tout formé* from the leaf to the root.

It is probable however that the actual mechanism of storage adopted posseses certain well-defined advantages; in the first place, if the sugars travel by simple diffusion, as has frequently been assumed, the rate of diffusion of the reducing sugars would be four times that of the cane sugar; moreover, as was emphasised by Brasse (1886), if the storage of cane sugar is accomplished by a direct wandering of this sugar as such from the leaf to the root, it would be in direct defiance of the ordinary laws of diffusion, as motion would occur from a place of low concentration to one of high concentration. If, however, the sugar is translocated as hexose and is immediately transformed in the root into saccharose, these objections no longer hold and a continuous stream of sugar could be maintained. It is probable, too, that the actual mechanism adopted serves to keep the cane sugar, once it is formed in the root, from getting out; de Vries' (1879) well-known experiment may be recalled, in which he showed that strips of beet-root could be soaked in water for 14 days without the presence of sugar being detected in the surrounding water. Gutzeit (1911) has also recently emphasised the impermeability to saccharose of the protoplasm of the cell-walls of the beet-root, pointing out that in the ordinary process of manufacture of sugar from the beet it is necessary to use hot water first, to kill the protoplasm, before the sugar can be extracted. Brasse (1886) showed that the same effect could be produced by chloroform. If the protoplasm is permeable to the hexoses and not to the saccharose a simple mechanism would exist by which the root could store up sugar without any possibility of loss by back-diffusion, and an explanation would be given of the fact that although the concentration of sugar in the root may be diminished after heavy rains by the inflow of water, the actual total quantity of sugar in the root steadily increases throughout the season's growth and never shows any falling off—Vivien, (1913). It has been generally assumed that, in the second year's growth of the beet, when the cane sugar is utilised to form new shoots, the saccharose is first inverted

by invertase in the root and is conveyed in the form of invert sugar to the growing points. But according to Colin (1915) invertase is not found in the root even in the second period of growth, when the seed-bearing plant is beginning to form; the saccharose is held to undergo inversion in the stalks and leaves of the new plant.

—"The Journal of Agricultural Science,"
February, 1916.

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**Education and Originality.**

THE nation must be educated to see that the men with high scientific and inventive ability in it, not by any means too numerous, constitute a national asset of inexpressible value. This power, when it exists, should not be allowed to dissipate itself in a struggle to secure the means of living, but be given an opportunity for the fullest exercise and use. There can also be no question that we have it in our power by suitable methods of education to develop such nascent ability.

Our present systems of education, and particularly the system of written examinations which are dependent so much on good memory for success, do much to destroy originality. In spite of all that has been written and said on this subject, we do not seem to be nearer to essential reforms. The object of all education is threefold: first to train character, will, and that power of selecting the best amongst various courses of action which we call right judgment; secondly, to impart necessary information and ability to do certain things well; thirdly to develop initiative and the power of handling new problems or investigations and a certain alertness in dealing with new situations. Our present methods of education are far too much directed to supplying ready-made and peptonised information. What ought to be made clear is that science must form not a mere adjunct but the actual foundation of the education given in secondary schools. In a word, what is wanted is a revolution in our educational system.

Unless the public appreciates the necessity for the change no such resolution is possible; when it does, the mechanism of converting the proposition into action will be simple. If the democracy once understands that we have no chance of keeping our place in the sun unless we are prepared to recognise that whether in peace or war science must be the dominant factor in education all difficulties will disappear.

But if this idea fails to take root our place will be lost; and such a place once lost can never be regained. The revelations which have come to light in the course of this bloody war will, we hope, do at least this good, that the people may be induced to appreciate the necessity of basing education upon natural science instead of upon the classics.

—"Nature," February 17, 1916.

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**The Ackee and Vomiting Sickness.**

Dr. Scott, who is Government bacteriologist in Jamaica, after a long and careful study, concludes that vomiting sickness, so prevalent in that island, is due to poisoning by ackee fruit, *Blighia sapida* There has been much difference of opinion as to the causation of this vomiting sickness, yellow fever and cerebro-spinal meningitis having been considered to be the cause of death in many of the cases in the past. Dr. Scott found in 1914-15 that ackees formed part of the last meal taken in health before the onset of the disease. Persons taking the "soup," or "pot-water," made with ackees in certain conditions, showed the most acute symptoms; the onset occurred in two hours, and death nearly always resulted. Unopened ackees, those picked from a decayed, bruised, or broken branch, those forced open unnaturally, and those with a soft spot are poisonous. Much of the poison is extracted by boiling with water. The affection is largely one of childhood. By experiment it was determined that intragastric administration of an extract, made by boiling unopened ackees with water, produced in three kittens and one pup the symptoms and pathological changes seen in cases of vomiting sickness. The pathological changes in man and experimental animals are described, and are well illustrated in two plates.

—"Nature," June 1, 1916.

# The District Gardens.

## Record of Attendances.

Under the name of "District Gardens," some of the Model Gardens, founded in 1908, and abolished by resolution of the Combined Court in March, 1915, have now been reconstituted. Below will be found the details of the attendances at these gardens from January to the end of September this year. It will probably be a considerable time before the numbers approach those recorded before the abolition of the Model Gardens, for the increasing interest and confidence of parents, teachers and children received a rude shock—and these things are plants of slow growth.

| Quarters. | Bourda. | Charlestown. | Belfield, E. Coast. | Stanleytown, New Amsterdam. | La Grange, W. Bank, Demerara. | Suddie, Essequebo. | Dem Amstel. | Houston, E. Bank. | Wakenaam. | Total Attendances. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1914. | | | | | | | | | | |
| First ... | 1,134 | 481 | 1,245 | 624 | 564 | 1,014 | 475 | 498 | 370 | 6,405 |
| Second ... | 1,047 | 489 | 1,008 | 699 | 322 | 726 | 428 | 425 | 263 | 5,407 |
| Third ... | 1,087 | 481 | 844 | 667 | 451 | 728 | 368 | 369 | 511 | 5,506 |
| Fourth ... | 975 | 535 | 772 | 453 | 536 | 557 | 520 | 351 | 389 | 5,098 |
| 1915:— | | | | | | | | | | |
| First ... | 1,123 | 641 | 1,006 | 769 | 1090 | 59 | 503 | 339 | 401 | 5,931 |
| Second ... | — | — | — | — | — | — | — | — | — | — |
| Third ... | — | — | — | — | — | — | — | — | — | — |
| Fourth ... | — | — | — | — | — | — | — | — | — | — |
| 1916 — | | | | | | | | | | |
| First ... | 910 | — | — | 35 | — | — | — | 169 | 195 | 1,309 |
| Second ... | 1,241 | — | 207 | 707 | — | — | 110 | 723 | 241 | 3,229 |
| Third ... | 1,347 | — | 384 | 372 | — | — | 289 | 616 | 620 | 3,628 |

## Exports of Agricultural and Forest Products.

Below will be found a list of the Agricultural and Forest Products of the Colony exported up to the end of September, 1916. The corresponding figures for the two previous years, and the averages for the four years previous to that, are added for convenience of comparison.

| *Product.* | *Average 1910-13.* | *1914.* | *1915.* | *1916.* |
|---|---|---|---|---|
| Sugar, tons ... | 39,705 | 52,294 | 63,795 | 51,798 |
| Rum, gallons ... | 1,437,841 | 1,949,135 | 2,933,524 | 3,136,192 |
| Molasses, casks ... | 757 | 832 | ... | ... |
| Molascuit, tons ... | 4,086 | 1,131 | 1,353 | 522 |
| Cacao, cwts. ... | 425 | 374 | 519 | 224 |
| Citrate of Lime, cwts. | 1 | 49 | 99 | 405 |
| Lime Juice, conc., gals. | ... | ... | ... | 5,703 |
| Essential Oil of Limes, gals. ... | ... | ... | ... | 241 |
| Coconuts, thousands | 681 | 1,516 | 1,546 | 1,130 |
| Copra, cwts. ... | 687 | 1,165 | 1,594 | 1,882 |
| Coffee, cwts. ... | 719 | 2,132 | 1,537 | 4,075 |
| Kola-nuts, cwts. ... | 3 | 4 | 2 | 21 |
| Rice, tons ... | 3,490 | 4,712 | 7,004 | 10,353 |
| Ricemeal, tons ... | 784 | 213 | 232 | 250 |
| Cattle, head ... | 748 | 951 | 460 | 504 |
| Hides, No. ... | 3,559 | 3,706 | 2,703 | 3,943 |
| Pigs, No. ... | 568 | 999 | 856 | 920 |
| Sheep, head ... | 21 | 131 | 4 | 27 |
| Balata, cwts. ... | 4,694 | 7,740 | 10,426 | 6,714 |
| Charcoal, bags ... | 52,526 | 54,327 | 42,786 | 43,249 |
| Firewood, Wallaba, etc., tons ... | 7,308 | 8,189 | 6,395 | 8,349 |
| Gums, lbs. ... | 2,327 | 886 | ... | 883 |
| Lumber, feet ... | 262,012 | 241,229 | 134,592 | 281,630 |
| Railway sleepers, No. | 2,691 | 6,127 | 1,056 | 4,325 |
| Rubber, cwts ... | 7 | 7 | 17 | 110 |
| Shingles, thousands | 1,818 | 1,639 | 1,539 | 1,672 |
| Timber, cub. ft. ... | 255,042 | 173,130 | 101,987 | 120,354 |

## Selected Contents of Periodicals.

*The Carbohydrates of the Mangold Leaf.*

*The Mechanism of the Degradation of Starch in the Leaf.*

The Journal of Agricultural Science, Feb., 1916.

*Historical Sketch of the Chemistry of Rubber.*

*The Anti-Science Manifesto.*

*The Neglect-of-Science Meeting.*

Science **Progress, July, 1916.**

*The Present Position and Future Prospects of the **Chemical** Industry in Great Britain.*

*The Importance of Scientific Research to the Industries.*

Science, September 29, 1916.

*The Organisation of Thought.*

*Linked Mendelian Characters in a New Species of Drosophila.*

Ibid: Sept., 22, 1916.